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Modes of representation about circular motion used by prospective teachers and predictions of instructors about these modes

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Abstract

This study aims to examine the modes of representation used by prospective teachers, taking the physics-I (mechanics) course of the primary mathematics education program in the Faculty of Education. The teachers' opinions were elicited about circular motion and the awareness of the instructors delivering the physics-I course regarding these modes of representation. A total of 107 prospective teachers participated in this study. 46 were female, and 61 were male. In this study, open-ended questions were used in order to discover the modes of representation used by prospective teachers when expressing their opinions about circular motion. After the questions were administered to the prospective teachers, 5 instructors teaching physics-I course were interviewed and they were asked to identify the modes of representation, together with the usage rates of the prospective teachers in answers to open-ended questions. In the study, it was seen that current situation regarding the modes of representation used by the prospective teachers while expressing their opinions about uniform circular motion, radial and tangential acceleration differs from the predictions of instructors, who presented the lesson.

Keywords: Uniform circular motion; Radial and tangential acceleration; Prospective teachers; Modes of representation
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1. Introduction

The increase in the use of writing as a learning tool in science courses is remarkable in recent years [1]. Writing to learn, which is a learning tool rather than an assessment tool [2], is regarded as making a strong contribution to students' science learning [3]. Writing to learn is of great importance for development of individuals in addition to its contribution to their science learning. It also serves different functions. In their studies, Mason and Boscolo [4] demonstrated that students could more easily achieve conceptual change through writing to learn.

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Traditional writing practices in sciences include comments, evaluations and explanations made by teachers in class in order for students to perceive science concepts, sentences written by students without thinking about explanations of topics in course books, and reports prepared about experiments conducted in the laboratories. These writing activities are more than just copying information and require students to have higher level cognitive skills [5, 6]. Researchers [7] have stated that, in science courses, students gave positive reactions to activities containing creative writing practices such as preparing a booklet, newspaper article, poster, letter, concept map and a slide presentation in contrast to traditional passive writing activities. It was seen that thinking in-depth to complete these different writing tasks improves students' ability to understand and remember science concepts. In addition, it was indicated that these activities enable students to establish connections between what they know, what they have learned and to better understand their learning methods, and contribute to an increase in their meta-cognitive awareness, sense of control and ownership of the learning process [7, 8].

A combination of tools, activities and representations in sciences is accepted as this discipline's way of processing data which makes modal representations essential [9]. Researchers [10] have demonstrated that use of representations of mathematical expressions containing modes such as text, graphics, tables, pictures, diagrams, lists, contributes to students' comprehensive and in-depth learning of the unit/topic studied. It is pointed out that, in recent years, tendency to representations such as diagrams, tables, text, graphics and animations together has increased and most effective learning theories emphasize the importance of multiple representations [11, 8]. In the literature, there seems to be a consensus about the fact that different modes must be understood, developed and used rather than students adhering only to particular modes when trying to represent and explain science concepts and phenomena [12].

It is reported by researchers that the use of multi modal representations and ensuring modal transformation may provide many advantages and that each modal representation serves a different purpose [13, 8]. Text and pictures are suggested for presenting or expressing a problem situation, a diagram is recommended to present or express qualitative data, a mathematical expression, and graphics are advocated for presenting or describing quantitative data. If a student knows the feature of each mode of representation and how to use them enables the student to achieve an in-depth understanding of the topic they are studying or thinking about [13]. It is argued that students noticing the relationship between modes achieve a better conceptual understanding under the guidance of teacher compared with students not having this information and that students able to transfer between different representations learn more effectively [12, 8]. Transfer between representations also configures the abstract concepts realizing the in-depth understanding of the learners [13]. It is argued that limitation of writing to learn activities containing multi modal representations (slide, text, word, page limitation) turns into an advantage leads students to better learn the topic and makes a positive contribution to academic achievement [1].

1. 1. Purpose of the study

1) The present study aims to reveal the modes of representation about circular motion used by prospective teachers, taking a compulsory mechanics (Physics-I) course, with their opinions about circular motion.

2) The present study tries to answer the question "Do instructors delivering the physics-I course aware of the modes of representation used by prospective teachers while expressing their opinions about circular motion, and the usage rate of these modes?"

2. Method

A total of 107 prospective teachers and 5 instructors participated in this study. 46 of the teachers were female and 61 were male. They were attending primary mathematics education program in the Faculty of Education and taking a compulsory mechanics course. Open-ended questions were used in the study in order to determine the modes of representation used by the prospective teachers while expressing their opinions about circular motion in a valid and reliable way by distinguishing them from predictions made by the instructors. The prospective teachers were asked open-ended questions after the topic of circular motion had been covered within the framework of semester program of a compulsory mechanics course. The prospective teachers' answers were obtained for each open-ended question related to the topic of circular motion and analyzed; answers were grouped according to the modes they contained. In addition, soon after the prospective had been asked, a face to face interview was conducted with 5 experienced instructors, who had delivered the mechanics course in the past years and in the semester in which the study was conducted, and were likely to continue teaching the course in the coming years in the same faculty. The instructors were asked to write the modes of representation used by prospective teachers while expressing their opinions in the answers they gave to the open-ended questions about circular motion, together with usage rate of these modes (4%, 10%, 15%,...). The arithmetic mean of the percentages related to each mode of representation taken from instructors was calculated and noted next to the related mode of representation. The modes of representation used by prospective teachers while writing answers to open-ended questions related to circular motion and the opinions of instructors delivering the physics-1 course about these modes of representation were presented in the same table but in different columns. The necessary comments and explanations about findings in the tables are given below the tables. Sample answers representing some of the modes of representation used by prospective teachers while expressing their opinions related to the circular motion are presented in the findings section.

3. Findings and comments

Question: 1) What do you think uniform circular motion is?

Table 1. Modes of representation used by prospective teachers while expressing their opinions about uniform circular motion and predictions of instructors about these modes

Modes of representation that can be used in answers	Prospective Teachers		Instructors
	N	%	%
Just using a word (text)	94	87.9	10.3
Just using formula	1	.9	14.0
Using text and formula together	-	-	12.8
Using text and figure together	-	-	13.0
Using text, figure and formula together	-	-	28.4
Using figure and formula together	-	-	16.3
Giving no answer	12	11.2	5.2
Total	107	100	100

It can be seen in Table 1 that prospective teachers use just two modes of representation while answering this question and they mainly (87.9%) try to explain through words.

Belirsel bir yol boyunca eşit zaman aralıklarında eşit yollar alan bir parçacığın hareketin düzgün dairesel hareket denir.

The importance of the present study can been seen in the fact that although the ratio of prospective teachers using the mode exemplified above is 87.9%, the instructors predicted that this mode would be 10.3%. The high rate of use of this mode by the prospective teachers may result from the technique and modal representation applied in the course in which uniform circular motion was covered. It is possible that, while covering this topic, instructors just gave an explanation but did not use other modes and teaching techniques. Moreover, the examples used and modes involved in these examples probably did not attract the attention of prospective teachers and so did not create the impression expected.

The predictions of the instructors, delivering a uniform circular motion (mechanics course) to prospective teachers in past years and likely to continue teaching the course in the coming years, about the modes of representation used by prospective teachers while expressing their opinions about these topics differ considerably from the research findings. As seen in Table 1, the instructors think prospective teachers can use all modes of representation. It is surprising that instructors predicted the use of "text, figure and formula" modes of representation, which was, in fact, not applied by any of the prospective teachers, as 28.4% and predicted those using "figure and formula" modes of representation as 16.3%. Instructors predicted the ratio of prospective teachers that wrote no answer as low. Predictions of instructors about prospective teachers writing no answer can be considered as a finding which indicates that they were not adequately aware of the prospective teachers understanding of circular motion.

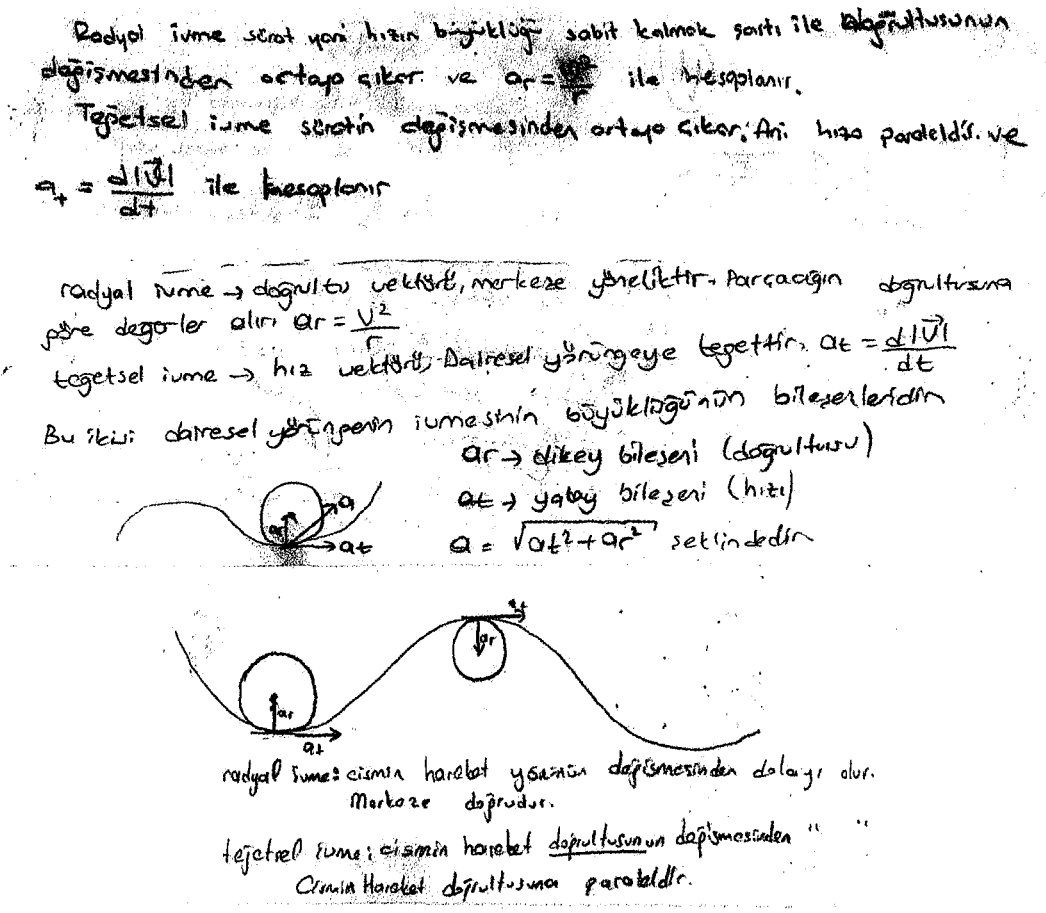
Question: 2) In your opinion, what are the features of radial and tangential acceleration?

Table 2. Modes of representation used by prospective teachers while expressing their opinions about radial and tangential acceleration and predictions of instructors about these modes of representation

Modes of representation that can be used in answers	Prospective Teachers		Instructors
	N	%	%
Just using words (text)	55	51.4	13.5
Just using formula ($a_r = v^2/r$; $a_t = dv/dt$)	2	1.9	12.1
Using text and formula together	22	20.6	10.5
Using text and figure together	3	2.8	13.4
Using text, figure and formula together	5	4.7	16.2
Using figure and formula together	1	.9	20.1
Giving no answer	19	17.7	14.2
Total	107	100	100

Examining the findings in Table 2, it is seen that all modes of representation are used by prospective teachers in different ratios and there are certain thought-provoking situations. While modes of representation with high rates of use were generally "just words" (51.4 %) and "text and formula" (20.6 %), other modes of representation were generally used at low levels. Findings in Table 2 reveal that the opinions of instructors about modes of representation used by prospective teachers do not correspond to the real situation, and there are considerable differences between the percentages. While the ratio of prospective teachers only using words (text) mode of representation is 51.4%, instructors predicted this as 13.5%; and while the ratio of prospective teachers using figure and formula together is 0.9% (~1.0%), instructors predicted this as 20.1%.

It is remarkable that although the ratios of prospective teachers using abovementioned "text and formula", "text, figure and formula" and "text and figure" modes are 20.6%, 4.7% and 2.8% respectively, the instructors predicted them very differently as 10.5%, 16.2% and 13.4%. The findings in Tables 1 and 2 show that instructors delivering the mechanics course at the university do not have adequate information about the modes of representation that prospective teachers can use while expressing their opinions about uniform circular motion,



radial and tangential acceleration.

4. Conclusion

The crucial findings of this study are that prospective teachers, who took a mechanics course in the Education Faculty, use various modes of representation with regard to radial and tangential acceleration and the usage rates of these modes are different from the predictions of instructors delivering the topic of circular motion to the prospective teachers. The instructors thought that the prospective teachers could use almost all the modes; in fact, the prospective teachers adhere to just one mode while defining uniform circular motion. This is confirmed by the results that although the ratios of prospective teachers using "just words", "text and formula", "text, figure and formula" and "text and figure" modes are 51.4%, 20.6%, 4.7% and 2.8% respectively to explain the topic of the features of radial and tangential acceleration, however, the instructors had thought these percentages to be 13.5%, 10.5%, 16.2% and 13.4%; furthermore the prospective teachers adhered to just one mode in the ratio of 87.9% while defining uniform circular motion, but the instructors predicted this to be 10.3% by instructors.

Various factors can be influential on choice of modes used by the prospective teachers while expressing their opinions about uniform circular motion, radial and tangential acceleration. It is probable that some of these factors are the methods, techniques, presentation tools and modes of representation used by the instructors teaching the topic circular motion to the prospective teachers. It is thought that further research on this issue will make important contributions to the field [14-22].

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